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Problem Analysis: Grizzly Bears and Coastal Development with Particular Reference to Intensive Forestry

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PROBLEM ANALYSIS:
GRIZZLY BEARS AND COASTAL DEVELOPMENT,
WITH PARTICULAR REFERENCE TO INTENSIVE FORESTRY

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Fish and Wildlife Branch

Ministry of Environment

Victoria, British Columbia

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INTRODUCTION

Development of coastal mainland forests appears to lead to declines in their grizzly populations. These declines will prevent management objectives for bears from being achieved. The major factors causing decline appear to relate to changes in hunting pressure and changes in habitat.

The Fish and Wildlife Branch is publicly committed to maintaining the diversity and viability of species representative of the major biophysical zones of the province. Since forestry development will reach virtually every major coastal mainland watershed within 25 years, it is incumbent upon the Fish and Wildlife Branch to develop management strategies that will realize Branch management objectives.

This problem analysis will identify the information base required before effective co-operative management strategies can be developed. Six major areas of research are outlined:

1. to determine population discreteness of coastal grizzlies;

2. to determine the nature, duration, and extent of dispersal;

3. to determine the seasonal habitat requirements of coastal grizzlies;

4. to assess the impacts of different forest practices on grizzly bear habitat and management;

5. to determine the ecological requirements for denning habitat and denning biology;

6. to determine if the concept of critical breeding areas applies to coastal grizzlies.

As well, non-research topics have been identified which are of equally high priority: development of an intensive information/education program to be delivered to all personnel working in coastal watersheds and development of a garbage policy for remote camps.

PURPOSE OF PROBLEM ANALYSIS

This Problem Analysis has two main purposes: to describe and examine management concerns relating to coastal grizzly bears and to identify and rank research questions that address these concerns to provide information to help managers meet objectives. A corollary purpose is to identify other actions necessary to meet management objectives.

OBJECTIVES OF GRIZZLY BEAR MANAGEMENT

Provincially

The grizzly bear is in the priority 3 provincial species group (Proposed Wildlife Management Plan for British Columbia). Provincial objectives for grizzly bears are to:

1. maintain grizzly bear populations at not less than 5,000 animals distributed in wilderness areas;

2. provide opportunities for people to view grizzly bears in their natural habitats;

3. provide 6,000 hunter days of recreation and an annual sustained kill of about 200 grizzly bears.

Provincial management prescriptions for grizzly bears are to:

1. identify and protect critical habitat especially salmon spawning areas and migration routes;

2. identify grizzly bear habitat, provide guidelines for development, and, where development may jeopardize grizzly habitat without offering commensurate benefits, oppose the development;

3. identify and remove problem bears in livestock areas and near settlements to minimize property damage and to prevent unnecessary killing of bears;

4. identify areas where grizzly bears may be safely viewed and designate those areas for public viewing;

5. co-operate with other jurisdictions in managing shared grizzly populations.

Regional management objectives are similar and parallel stated provincial objectives (Draft preliminary regional plans for Regions 1, 2, 5, and 6).

Objectives shared among regions include maintaining present grizzly bear numbers (Region 6 recognizes that present grizzly bear numbers may have to be slightly reduced); allowing recreational hunting opportunities; reducing man-grizzly bear conflicts in wilderness areas; and, providing opportunities for viewing grizzly bears in wilderness settings.

GENERAL CONCERNS OF MANAGERS

1. Grizzly bears have low population growth rates and consequently are vulnerable to overharvesting.

2. There is no reliable inventory method for grizzly bears, making local population management impossible.

3. The seasonal habitat requirements of grizzlies are largely unknown. This prohibits effective habitat protection in the face of increasing habitat alteration.

During the course of collecting information for this problem analysis, many individuals were contacted and interviewed. The contributions of the following are acknowledged: Ernie Beadle, Ministry of Forests (MOF); Marty Beets, Ministry of Environment (MOE); Jack Bone, MOE; Fred Bunnell, U.B.C.; Tom Burgess, MOE; Brian Downie, MOF; Al Edie, MOE; R. Ellis, MOF; Paul Haley, MOE; G. Hartman, Federal Fisheries; Sally Leigh-Spencer, B.C. Forest Products; Jack Lentfer, Alaska Fish and Game; Kevin Lloyd, N.W.T. Fish and Wildlife; Bruce McLellan, U.B.C.; Rick Morley, MOE; Doug Morrison, MOE; Brian Nyberg, MOF; Tom Smith, MOE; David Tait, U.B.C.; Rai Thomas, MOF; Ben Van Drimmelen, MOE.

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Don Eastman provided the initial direction for this problem analysis and reviewed the manuscript in draft form. His contribution is also gratefully acknowledged.

THE SETTING

STUDY AREA

The study area will be a watershed on coastal British Columbia. We decided to study a coastal population of grizzlies for the following reasons:

1. There has been a considerable amount of research conducted on interior and northern grizzlies (Craighead et al. 1974; Martinka 1974; Pearson 1975; Russell et al. 1979; Hamer et al. 1979; Hechtel 1980; Reynolds 1980). By comparison, little work has been done on coastal grizzly bears. Few data relating to movements, ecological relationships, and reproductive parameters have been gathered.

2. Coastal watersheds appear to support high density grizzly populations which may provide recreational sport hunting opportunities for a growing number of grizzly bear hunters, as well as provide opportunities for viewing. To guard against overharvest, certain demographic and reproductive data specific to the coastal ecotype are required.

3. Development is imminent in every major coastal watershed. To meet provincial and regional objectives relating to grizzly bears, information is required to minimize the impacts of coastal development on grizzly bears.

BIOPHYSICAL SETTING

The majority of B.C. coastal forests fall within the Coastal Hemlock, Coastal Douglas Fir, and Subalpine Mountain Hemlock forest zones defined by Krajina (1965). Russell (1974) provides the following description of a typical coastal watershed: deep narrow valleys with steep cliffs, ending in productive estuaries and bounded by rugged mountains with heights up to 2500 m.

The habitat types found in most coastal watersheds range from heavily treed valley bottoms to alpine. Representative tree species in the forested zones are western hemlock[1], Sitka spruce, western red cedar, amabilis fir, and Douglas fir. Understory forbs and shrubs vary with site conditions. Common species are huckleberry, false azalea, ferns, mosses, and bunchberry. On poorly drained sites, skunk cabbage, devil's club, and salmonberry occur. The wetter sites support alder and sedges. Avalanche sites are common and the plant community present represents early successional stages. Snow remains longer on north-facing avalanche slopes than on valley floors and receding snow provides a continuum of phenological stages of plants.

RESOURCE DEVELOPMENT

The principal resources currently being exploited in coastal watersheds are forests, fisheries, and wildlife.

The forestry resource:

The annual economic value of timber harvested in coastal mainland watersheds is estimated to be between 1 and 2 billion dollars (Mike Whybrow, pers. comm.).

The fisheries resource:

The annual economic value of the coastal mainland commercial salmon fishery is estimated to be 225-250 million dollars (Jim Fralick, pers. comm.). Sports fishing in coastal inlets and along coastal rivers is becoming increasingly popular. As well, there is a sport-fishing/guiding business in many coastal watersheds that is locally important.

The wildlife resource:

Wildlife in coastal watersheds is locally important as a souce of income (trappers, guides), protein (sport hunting), and recreation.

The economic benefits derived directly from the use of grizzlies is lower than forest or fisheries values in coastal watersheds. However, the true value of coastal grizzlies is only partly economic. Grizzlies have additional values: non-consumptive uses, the vicarious value of knowing that coastal grizzlies are present, and the genetic value of these populations. These are values difficult to quantify in dollars.

Grizzly populations throughout the world have been decreasing rapidly in the past 400 years to the point where the only viable populations in North America may reside in the last remaining tracts of wilderness. Bunnell and Tait (in prep.) suggest that established national parks in western Canada and the contiguous areas of the United States are not large enough to ensure viable grizzly populations if sport hunting continues and depredation (livestock) hunting also exists. Thus, the value of grizzlies in wilderness areas and the importance of ensuring the long-term welfare of these bears would increase. When a resource is a diminishing global commodity, international attention will be focused on the status of this resource.

[1]Common and scientific names of animal and plant species mentioned in the text are listed in Appendix A.

CURRENT STATUS OF COASTAL GRIZZLY BEAR RESEARCH IN BRITISH COLUMBIA

Since the early 1970's, coastal grizzly bears have been identified as a high priority species for research by those Fish and Wildlife Branch Regions with coastal areas (Regions 1, 2, 5, and 6). Early attempts to form a provincial grizzly research steering committee for coordinating and directing this type of research were unsuccessful. Consequently, some Regions undertook independent research projects.

Region 1 has been most successful to date in their attempts to address the research needs of coastal grizzlies. In several coastal watersheds within the Region, studies have been sponsored to investigate the food habits of coastal grizzly and black bears and the effects of logging on bear habitat (Russell 1974; Wray 1975; Smith 1978; Lloyd 1979).

Region 2 has limited their coastal grizzly investigations to watershed surveys. Track counts along rivers are used to estimate relative abundance of bears, an index found to be useful for bear management purposes in this Region. Research requirements have been identified and include: grizzly ecology, inventory techniques, and assessment of the effects of waste disposal practices on bears.

Region 5 has conducted coastal watershed surveys (track counts) since 1971. As well, a number of proposals to conduct research on coastal grizzlies have been prepared in the past four years. Insufficient funds have prevented this Region from engaging in any independent research to date. However, British Columbia Forest Products (B.C.F.P.) has been conducting some research on coastal grizzlies in the Machmell-Genessee River areas, and Regional personnel have been peripherally involved in this project.

Region 6 has identified research on coastal grizzlies as a high priority and is committed in principal to a long term project to address their management concerns.

Research on coastal grizzlies faces major difficulties. Most potential study areas are isolated, making access costly. The field work is very expensive and labour intensive. The wet climate, lack of access, and rugged terrain make working conditions adverse. Also, the species is mobile and potentially dangerous. Consequently, to minimize costs and hazards, the Fish and Wildlife Branch proposes that one comprehensive research project should be designed to deal with the management concerns and problems relating to coastal grizzlies.

THE PROBLEM

GENERAL PROBLEM

Grizzly bears appear to demonstrate great niche plasticity, as evidenced by their wide distribution. Historic records reveal a holarctic distribution with

southern extensions approaching tropical climates (Cowan 1972). In North America, grizzly bears were found as far south as central Mexico and east to the Mississippi (Craighead et al. 1974).

Current distribution records reveal that grizzlies are now found only in pockets of their former range. In North America, these pockets represent large tracts of wilderness, such as the contiguous area of British Columbia, Yukon, and Alaska, or are islands of wilderness such as the mountain National Parks in British Columbia, Alberta, Montana, Idaho, and Wyoming (Cowan 1972; Craighead et al. 1974). Common to both types of areas are grizzly populations protected from overhunting, either through logistics or legislation, and few man-bear contacts. After an intuitive evaluation of these facts, two conclusions could be drawn: grizzly bears require wilderness for survival and bears are incompatible with man. This incompatibility is apparent in British Columbia. Grizzly bears have been extirpated from the southern Okanagan Valley as well as many of the south-coastal watersheds of the province. The question then is to determine if this pattern can be broken for the remainder of coastal British Columbia.

SPECIFIC PROBLEMS

Forestry activity in coastal watersheds will continue to increase in British Columbia. Downie (pers. comm.), Regional Forest Manager, Prince Rupert Region, Ministry of Forests, advises that almost every major coastal watershed in the central and northern coastal areas is slated to be logged within 25 years. This means that most, if not all, of the coastal grizzly populations will be subject to impacts relating to forestry activities in the near future.

Increasing coastal logging activity and the resultant watershed habitat alteration, as well as a probable increase in man-induced bear mortality through sport hunting and/or problem bear control, does not bode well for the future of coastal grizzlies.

To preserve grizzly populations in coastal watersheds, co-operative planning strategies between the Ministries of Forests and Environment will be required. A series of interviews were conducted with representatives from both ministries, the forest industry, and Federal Fisheries to determine what information was required before the planning process could be successful. As a result of these meetings and a literature review, the following list of information needs was identified.

1. How is a coastal grizzly population defined?

2. What constitutes critical habitat?

3. Can a reliable inventory technique for coastal grizzlies be developed?

4. Can a waste management system be developed and implemented that will eliminate bear-human-camp-dump problems?

5. What are the effects of logging old growth coastal forests on grizzly bear habitat?

6. What are the effects of intensive second growth forest management on grizzly bear habitat?

7. What are the cover requirements for coastal grizzly bears?

8. Can temporal variation of cutting prescriptions be conducive to coastal grizzly populations?

9. What are the specific forest cover requirements? Is there a preference for coniferous - mixed stands over deciduous stands?

10. At what point in time will grizzly bears start to use clear cuts?

11. Is noise a disturbance factor for coastal grizzly bears?

12. Are population declines normally associated with habitat alterations attributable exclusively to this factor?

13. What is the effect of logging on bear movement, density, and population composition?

14. What are the ecological denning requirements of coastal grizzly bears?

15. Are management prescriptions employed for interior grizzly bear populations applicable to coastal populations?

16. What is the reproductive potential of coastal grizzly bears and population growth rate?

17. How mobile are coastal grizzly bears?

18. How does disturbance affect bear behaviour?

19. What are coastal grizzly bears' seasonal food preferences?

20. What are the factors governing denning behaviour? Are they sex/age specific?

21. Are there seasonal movements of bears to preferred feeding sites? How critical are these sites?

22. What are the habitat requirements for grizzly bears feeding on salmon?

23. What logging procedures are compatible with grizzly bears?

24. Can security and spatial requirements be defined seasonally?

25. What policies of remote camps are compatible with grizzly bears?

26. What are the attitudes of front-line resource extractors towards grizzly bears?

27. If these attitudes are negative, what impact does this have on local grizzly populations?

28. If these attitudes are negative, how can they best be reversed?

ANALYSIS OF PROBLEMS

The extensive list of identified information needs can be divided into two basic problem areas for research: habitat - related research and population - related research.

Habitat - related research

Many feel that coastal logging and grizzlies are incompatible, and view the coastal development scenario as leading to the demise of this bear ecotype. This belief is substantiated somewhat by the work of Russell (1974) who concluded that coastal grizzly bears are incompatible with clear cutting, the forest practice generally employed in coastal watersheds. However, a clear cause and effect relationship between coastal logging and grizzly population declines does not exist. For example, Smith (1978) documented the presence of grizzlies in a logged watershed because:

1. there were few bears killed before, during, or after logging;
2. less than one-half of the valley floor under 610 m was logged;
3. the disturbed areas were in maximal shrub production;
4. post-logging industrial and human presence did not occur.

The implication of Smith's (1978) findings are that habitat alteration as a result of logging may not be the exclusive reason for grizzly declines in coastal watersheds. Some researchers studying interior grizzly populations believe that man-induced mortality associated with forestry contribute more to grizzly population declines than habitat alteration (Craighead 1977; Jonkel 1977).

Population - related research

To achieve management objectives for coastal grizzly bears, population sizes and optimum harvest levels must be determined.

It is clear that habitat - related problems associated with forestry cannot be divorced entirely from population - related problems. A myriad of ancillary problems associated with forestry development have a confounding effect on grizzly bear population management. For example, forestry access roads provide legal hunters with the capability to hunt unexploited populations. Man-bear conflicts associated with logging or recreational activities in these watersheds often develop. Poaching is a problem: illegal hunters have access to seasonal concentrations of coastal grizzlies in areas where enforcement effort is minimal due to high costs of patrolling and insufficient enforcement staff.

Other problems

Non-research items are also identified in the list of information needs. These relate primarily to information/education and waste management in remote camps.

RESEARCH TOPICS

HABITAT-RELATED TOPICS

The majority of questions outlined by forestry and wildlife managers revolved around the effects of forestry on bear habitat and bear management. Before we can quantify the effects of forestry on coastal bears, we must first have a clear understanding of the existing relationships between coastal grizzlies and the biotic and abiotic components of their environment.

Habitat factors traditionally recognized as limiting for wildlife populations are food and shelter. Each factor as it relates to coastal grizzlies will be discussed separately.

Food

The grizzly bear is a highly adaptable omnivore, exploiting a wide variety of food sources in many different ecosystems. The foraging strategy of grizzly bears is to gorge on high energy foods during the late summer - early fall, presumably to put on sufficient fat reserves to last through the period of winter dormancy (Sizemore 1980). Daily weight gains reported during this period by Pearson (1975) were 0.413 kg/day over 126 days for an adult grizzly, and for an immature female 0.635 kg/day over a 16 day period. Conversely, weight losses from fall to spring are significant. Pearson (1975) reported an average percent body weight loss over this period for four grizzly bears of 33 percent. Russell et al. (1979) reported similar weight losses in Jasper, Alberta. The heavy reliance on weight gains during the summer-fall makes this period a critical time in the life history of individual bears.

Recent work suggests that plant food does not control grizzly home range size. Hamer et al. (1979), working on habitat use by grizzly bears in Banff, have intensively studied the foraging behaviour of grizzly bears. These workers found that grizzlies seldom feed on vegetation until it is exhausted, and that there is sufficient plant food in a relatively small area to sustain a grizzly, in comparison to the wide areas over which these bears normally range. This contention is further substantiated by the work of researchers who have reported that female grizzlies with cubs of the year have the smallest home ranges of any cohort of the population (Pearson 1975; McLellan 1980; Reynolds 1980). Logically a female with cubs should require the largest area of any cohort because of the higher energy demands of lactation and juvenile dependency. That the converse is true strongly suggests that home range size is not associated with energy available from plants.

When viewed from an evolutionary perspective this makes sense. The grizzly evolved as a predator and has the digestive system of a carnivore. When bears rely heavily on vegetation, the plants must be highly nutritious and easily digestible (Hamer et al. 1979; Lloyd 1979; Sizemore 1980). Hamer et al. (1979) hypothesized that the grizzly moves randomly through its home range, searching for animal food items. Other investigators have observed the preference of bears for animals as opposed to plants (Craighead 1977; Johnson 1980). This suggests that where animal food items are available seasonally, bears will exploit them

rather than plants. The heavy reliance on anadromous fish runs, (Troyer and Hensel 1964; Lloyd 1979; Johnson 1980), carrion (Johnson 1980; McLellan 1980) and garbage dumps (Cole 1973; Craighead et al. 1974) enforce the concept of grizzly bears as being opportunistic, adaptable feeders that will exploit high energy animal food when available but are able to subsist on a wholly vegetative diet when necessary.

Work done on coastal grizzly feeding habits has identified seasonally important food sources that include sedge/carex meadows, berry-producing areas, and anadromous fish streams (Russell 1974; Smith 1978; Lloyd 1979; Johnson 1980).

The early green-up areas, such as the sedge/carex meadows and skunk cabbage sites associated with estuaries appear important to coastal grizzlies emerging from dens in the spring (Al Edie, pers. comm.) Russell (1974) documented the movement of coastal grizzlies to the estuaries in the spring, with subsequent movement up the valleys following snow melt. Russell hypothesized that this movement was in response to phenological changes resulting from the receding snows.

Logging activities should have no direct impact on sedge/carex meadows and skunk cabbage sites. However, logging could have indirect effects by altering existing water regimes, and by using estuaries for camp placement and booming grounds. Probable consequences of these actions would include a modification of seasonal grizzly distribution and development of man-bear conflicts. The worst possible case would result in a reduction in the carrying capacity of the watershed for grizzlies.

Berry-producing areas may be locally important and seasonally vital to coastal grizzlies, as berries are consumed during the critical late-summer, fall weight gain period (Lloyd 1979). In most cases, logging will result in an increase in berry production and berry quality (Smith 1978), since berry-producing plants are shade intolerant and early successional species. Extensive clear cuts would result in a initial flush of berries, with an eventual decline as the forest canopy closed. This decline in berry crops could be detrimental to bears.

Some intensive silviculture practices will have a detrimental effect on grizzly bear food. Broad-leaved plant control by herbicides to encourage seedling production eliminates berry plants. Other silviculture techniques such as juvenile spacing and fertilizing may also adversely affect grizzly bears. Conversely, managed stands may be better for grizzlies than natural stand regeneration.

Work done on coastal grizzly feeding habits have all reported the importance of anadromous fish runs (Troyer and Hensel 1964; Russell 1974; Smith 1978; Lloyd 1979). These fish runs unquestionably constitute a critical component of the coastal grizzly's annual food intake. Preserving stream (river) integrity and, therefore, salmon runs is required by the Federal Fisheries Act. The most commonly used technique to preserve streams involves leaving timber strips along rivers, the nature and extent of such strips dependent on local conditions. Because of the importance of these salmon rivers to grizzly bears, quite possibly on an inter-watershed level, it is necessary to protect the integrity of these rivers. Also, as will be outlined later in this report, the leave strips themselves may play an important role in grizzly ecology.

In conclusion, food does not appear to be a limiting factor in undisturbed coastal watershed. Seasonally important food areas have been identified. Logging practices which preserve the integrity of these areas should ensure that there will be sufficient food for bears.

Shelter

Shelter requirements for grizzly bears can be broken into two components: long term (denning) and short term (daily needs).

Denning evolved as a strategy to survive in an environment that lacks sufficient food over extended periods of time. While the grizzly bear is not a true hibernator, there is a period of inactivity during the winter months, the length of which seems to depend on latitude and annual snow accumulations (Craighead and Craighead 1972; Lentfer et al. 1972). Late summer-fall hyperphaging of high energy food allows for sufficient fat reserves to sustain grizzlies through the period of winter dormancy (Lloyd 1979).

The denning biology of grizzly bears is poorly understood. Pearson (1975) suggests that the denning impulse must be a combination of physiological and environmental factors that affect sex/age classes differently. In some areas, dens are constructed far in advance of their use (Craighead and Craighead 1972; Pearson 1975), whereas Reynolds (1980) reported that grizzly bears on the north slope of Alaska selected, excavated, and occupied dens within a 2-3 day period.

There are both variations and similarities in denning characteristics between studied populations. Dens appear generally to be actively excavated (Craighead and Craighead 1972; Pearson 1975; Reynolds 1980). The soil must be suitable for excavation but yet have the structural strength to avoid slumping. In the north, grizzlies excavate after frost has entered the ground (Reynolds 1980), and in other areas, they excavate in the vicinity of shrubs, since the roots of these shrubs will afford soil stability (Pearson 1975). Also, dens are excavated in areas of high snow accumulation (Pearson 1975). Specifics of site selection, such as elevation, slope, and aspect, vary.

Bears may abandon winter dens if disturbed (Harding and Nagy 1980). If disturbance occurred when the probability of survival was low, or after the birth of cubs, it would have detrimental effects on the population. Since logging is so widespread in coastal bear habitat, the ecology and biology of denning by coastal grizzlies must be better understood to minimize disturbance.

Short term cover requirements are those used by bears in the course of their daily activities.

Grizzly bear habitat ranges from boreal forest to alpine and tundra. There is some suggestion that cover requirements may vary according to whether or not a population is hunted. Smith (1978) observed grizzly bears in slash areas. This population had been subjected to virtually no hunting pressure. Russell (1974) reported that his hunted population of grizzly bears avoided slash and other open areas and appeared to require cover for movement. One implication of Russell's (1974) and Smith's (1978) findings is that bears may modify their behaviour in hunted areas by moving through protective forest cover. Smith (1978) also reported observing grizzly bears moving through slash areas with great difficulty. This suggests that the site treatment after logging may play a role in determining the attractiveness of post-logging areas to bears.

Although seemingly not critical for daily movement in an unhunted population, forested areas may still play an important role in providing short-term cover requirements. Lloyd (1979) suggested that since coastal grizzly bears inhabit a much lusher, denser habitat than other grizzlies, they have developed mechanisms for spatial and temporal separation to avoid intraspecific aggression. These cues include trail marking and tree marking. Pearson (1975) reported that agonistic behaviour between grizzlies occasionally results in death. Stringham (1980), in his summary of six grizzly populations, reported that adult male-induced mortality on other grizzly bears may be higher in feeding aggregations. If so, then mechanisms described by Lloyd (1979) for separating bears during feeding aggregations may be critical. Also, leave strips assume added importance as visual screens that reduce intraspecific strife and thus, stress and mortality.

In conclusion, the need to prevent disturbance on denning areas appears critical, but denning habitat is unknown. Visual screens may be critical during seasonal aggregations of coastal grizzlies. The importance of security cover for movement has been recognized but not clearly shown to be critical.

Objectives

- determine the ecological requirements for denning habitat.
- determine coastal grizzly denning biology.
- assess the importance of movement corridors to coastal grizzlies in hunted and unhunted populations.
- determine the importance of visual screens during seasonal aggregations of coastal grizzlies.
- document grizzly bear response to different cutting regimes.
- determine grizzly responses to different site treatments following logging.
- assess the relative importance of different cutting regimes on coastal grizzly management.

POPULATION-RELATED TOPICS

Population-identity

Russell (1974) first raised the question of inter-watershed travel by grizzly bears as a means to exploit high energy food concentrations, such as those associated with anadromous fish runs. Smith (1978) employed a number of techniques to document the presence of grizzly bears on a coastal watershed that lacked a significant salmon run. During the month of August, the incidences of grizzly activity dropped off to nearly zero. At the same time, Lloyd (pers. comm.), working on an adjoining watershed with a heavy salmon run, recorded a great increase in grizzly activity It is unclear whether this increase was a seasonal aggregation of grizzlies resident in the watershed, an immigration of bears from neighbouring watersheds, or a combination of both.

Lloyd (1979) confirmed inter-watershed movements by coastal grizzly bears. Because the degree and extent of these inter-watershed movements is unknown, confusion exists on how to define a coastal grizzly bear population.

Research conducted on interior and northern populations of grizzly bears reveals that home range size is a function of habitat productivity (for example, compare Pearson 1975 with Reynolds 1980). Exclusiveness of individual home ranges appears to be a function of habitat homogeneity (Bunnell and Tait 1981). In bear ranges where food sources are evenly distributed and predictable, bears will tend towards exclusive home ranges (Pearson 1975; Nagy and Russell 1978; Russell et al. 1979), at least between some sex and age classes. Alternatively, in areas where there are high energy food concentrations, whether naturally occurring or man-induced, bears will congregate at least seasonally (Troyer and Hensel 1964; Craighead et al. 1974; Lloyd 1979). As well, it has been demonstrated that reproductive potential and consequently population growth rates are strongly tied to nutrition (Bunnell and Tait 1981). Stringham (1980) grouped grizzly populations according to habitat quality and found significant differences in age of first reproduction and average litter size.

Coastal forests are among the lushest areas inhabited by grizzly bears in North America. Since density is a function of home range size and exclusiveness, and habitat quality, one would expect high densities of grizzly bears in coastal watersheds.

Preliminary work conducted on coastal B.C. watersheds has confirmed this prediction of high densities. Wray (1975) reported that the Ahnuhati River supported a minimum of 20 grizzly bears during salmon spawning. The Ahnuhati and all of its tributaries measure approximately 70 km in length, with an overall area of less than 100 km^2. The resultant density estimate of 1 grizzly/5 km^2 is much higher than densities reported for interior and northern bears (Martinka 1974; Pearson 1975; Russell et al. 1979; Harding and Nagy 1980; Reynolds 1980), but is comparable with densities reported for other coastal populations. For example, Troyer and Hensel (1964) reported a density for Kodiak bears 1/1.6 km^2 and Johnson (1980) reported 1 grizzly/4.2 km^2 on coastal islands in southeast Alaska.

The question remains then as to how to define a coastal population. Rich habitats such as coastal forests appear to support high bear densities, and, given that all of the living requirements (food, water, shelter, denning) are likely found in each watershed, perhaps each watershed supports its own discrete population. Documented inter-watershed movements does not support this premise. To define population discreteness, the extent and frequency of inter-watershed movements must be understood and the segment of the population which exhibits this behavior must be determined.

1. Inventory Techniques

Population management is traditionally based on the concept of directing hunting effort towards the harvestable surplus of a population. To manage populations effectively employing this strategy, the manager must know population size and discreteness as well as certain demographic parameters. It is apparent that for a coastal grizzly research program to have any management application, it must develop a procedure for estimating densities. Three methods have been tried: track counts, direct counts (ground and aerial), and mark-recapture.

Klein et al. (1958; cited in Edwards and Green 1959) first described the use of track measurements as an inventory technique for coastal grizzly bears, but later reported that his technique was unreliable (Klein 1959). Edwards and Green (1959) tested this technique in coastal British Columbia and generally concurred with the findings of Klein (1959), although they felt the technique may have application in low density grizzly areas. Lloyd (1979) agreed with the statements of Edwards and Green, and also found that under ideal tracking conditions black bear tracks can be distinguished from grizzly bear tracks.

The first comprehensive, quantitative effort to inventory bears was by Erickson and Siniff (1963). They statistically evaluated the feasibility of using aerial surveys as a technique to inventory coastal brown bears in Alaska. Their findings indicated that this technique had little value because they could not control or measure the myriad of variables, and because the high number of flights required to achieve acceptable results was too costly.

In spite of the shortcomings of counts and track counts, both techniques continue to be used in coastal B.C. (Burgess 1980), presumably because a better method is not available.

A common procedure used to estimate densities of mammals is the capture-recapture technique. In Kluane, Pearson (1975) felt that his mark-capture technique was exhaustive over his study area and he based his density estimates on this contention. Using a tranquilizer gun, he immobilized free-ranging bears from a helicopter. Given that Pearson's study area consisted predominately of alpine and subalpine regions with high visibility and little escape cover for bears, his contention seems logical. In his work on interior grizzly bears in the southeastern portion of B.C., McLellan (pers. comm.) believes that his trapping effort is exhaustive, and that bear numbers can be estimated from the asymptote of number of new captures against time.

The reliability and accuracy of this technique is open to some question. In the work conducted by Troyer and Hensel (1964), it appeared that certain sex/age classes were more susceptible to traps than were others. They suggested that trapping may be selective for younger bears because their smaller feet make them more liable to be captured. Bunnell and Tait (1980) discuss differential vulnerabilities of bears to hunting pressure and the same concepts would apply to live-capturing bears. In fact, Bunnell (pers. comm.) contends that density figures and population models derived from using either kill data or live-trapping data mask the actual situation because of this differential vulnerability.

The problems associated with coastal grizzly research preclude the use of inventory techniques applied elsewhere. Direct observational counts are impossible for most of the year, and counting bears along rivers during salmon runs will be of little value until the question of population discreteness is resolved. Capture-recapture techniques appear to be misleading and labour intensive to the point of being prohibitively expensive in coastal forests.

The lack of a reliable inventory technique for coastal grizzlies and the confusion surrounding population discreteness for coastal grizzly populations precludes traditional population management techniques. However, grizzly populations can be effectively managed in the absence of inventory information. The refuge concept of population management can be applied to grizzlies. A block is designated as a no hunting area. This area will become a reservoir, providing

neighbouring areas with overflow bears that would represent the harvestable surplus. To adopt this type of strategy, it is not necessary to know population size. However, it is vital that population discreteness and the mechanisms governing dispersal be known. These data are necessary to establish reservoir size.

2. Objectives

- document the nature and extent of inter-watershed movement by coastal bears.

- determine the nature, duration, and extent of dispersal in coastal grizzlies.

3. Hypothesis to be tested

Inter-watershed travel is unique to dispersing subadults. Adult bears demonstrate watershed fidelity.

Population demography

Population growth rates are a function of birth rates, mortality rates, and dispersal. In general, the grizzly bear is a species which exhibits low birth rates, low mortality rates, and a long life span. Consequently, the population growth rate for grizzly bear is slow. Bunnell and Tait (1980) constructed a population model and recommended that hunting mortality rates should not exceed 5 percent of the population.

Compared with other ecotypes, coastal grizzlies have a high reproductive rate and, therefore, a high population growth rate. In a summary of many grizzly studies, Bunnell and Tait (1981) suggested that coastal grizzlies may have larger average litter sizes than northern or interior grizzlies. As well, the interval between litters may be less for coastal grizzlies than for other populations (Spencer pers. comm.). If coastal grizzlies have higher population growth rates than other populations, they would be able to sustain higher (hunting) mortality. Further, once extirpated over an area, coastal grizzlies may be able to reach carrying capacity more quickly than previously thought, given that neighbouring populations remained secure.

However, other data do not support the concept of higher population growth rates for coastal grizzlies or other populations exhibiting seasonal concentrations. High reproductive rates may be balanced by high cub mortality. Stringham (1980) summarized six grizzly studies and reported that cub mortality may be greater in feeding aggregations of grizzlies. Craighead et al. (1974) reported a 31 percent mortality of cub-of-the-year in Yellowstone Park where bears congregated at garbage dumps. These findings parallel those of Glenn et al. (1976) who reported 38 percent mortality of this age class in grizzly bears congregating at salmon streams.

The sex and age structure of a population will also affect population growth rates. Because of the vulnerabilities of different age and sex classes to capture or harvest (Bunnell and Tait 1981), this type of information is exceedingly difficult to obtain. An excellent theoretical treatise of this subject is given by Bunnell and Tait (1981).

The reproductive behaviour of grizzly bear exhibits great plasticity throughout its range. Craighead et al. (1969) reported that grizzlies would come together, copulate, then return to feeding at a dump, all within a few hours. Herrero and Hamer (1977) observed a different mating sequence: a male grizzly actively confined a female grizzly to an alpine ridge for 13 days with copulation occurring on the final day of confinement. They hypothesized that this strategy had evolutionary significance since the male would be isolating the female from other breeding males, thus guaranteeing his fitness and the female would be ensuring the fitness of her progeny by mating with a dominant male. This mating sequence was observed in other portions of their study area, suggesting that these mating ridges were critical areas.

The mating sequence of coastal grizzlies is unknown. If estrus coincides with feeding aggregations, then the reproductive behaviour reported by Craighead et al. (1974) may occur. Alternatively, if the reproductive strategy reported by Herrero and Hamer (1977) occurs and if the mating ridges or other areas are indeed critical, then they should be identified and protected.

1. Objectives

   - determine the birth rates for coastal grizzlies.

   - determine cub survivorship.

   - determine the reproductive interval.

   - document the reproductive strategy for coastal grizzlies.

2. Hypotheses to be tested.

   - The population growth rate for coastal grizzlies is greater than that reported for other populations of grizzlies.

   - Due to high bear densities, the dense vegetation in valley floors, and the seasonal concentration of food, the concept of critical mating areas applies.

Predators

Mortality of grizzly bears through predation is attributable almost exclusively to conspecifics and man, although there are scattered reports of wolves attacking grizzlies (Bunnell and Tait 1981). Grizzlies have evolved strategies to avoid intraspecific strife. For example, investigators have reported that females with cubs of the year have restricted ranges, probably to avoid adult males (Pearson 1975; Russell et al. 1979). Another hypothesis is that dispersal is largely a density dependent function which has survival value for subadult bears (Bunnell and Tait 1980). However, the grizzly has not evolved strategies to deal with predation by man with a high powered rifle.

Cowan (1972) in a comprehensive review of the status of bears throughout the world suggested that grizzly bears were able to co-exist with man until the advent and wide circulation of firearms. Pearson (1976) suggested that the grizzly is a very adaptable species in terms of habitat requirements and that it is man, not grizzly, which is the species unable to adapt. Pearson (1976) uses National Parks

as an example of grizzly bears' adaptability - they do not require large areas devoid of man's activity and presence to survive. Bunnell and Tait (1981) substantiate the comments of Cowan (1972) and Pearson (1975, 1976). They believe that when man is considered a predator in a predator-prey relationship with grizzly bears, then man is the major limiting factor. Bunnell (pers. comm.) believes that man-induced mortality has been the main reason for population declines of the grizzly throughout its range. Craighead (1977) believes that man-induced mortality is more of a limiting factor than habitat destruction.

Given that man-induced mortality has played a major role in population decline and extirpation, we must consider this factor in the context of coastal grizzlies. Man-induced mortality on bears is a function of two activities: direct and indirect mortality through hunting, and mortality associated with man-bear conflicts. Since the grizzly regulations were amended in 1974/75 (separate fee for grizzly and increased trophy fees), the demand for grizzly bears has increased steadily. This increase has averaged 20 percent per year over the past five years for resident hunters, and 16 percent annually for non-resident hunters. Clearly, there is an increasing demand for this valuable trophy species. Hunters desiring a pristine hunting experience with a high probability of hunting success can be expected to move into coastal watersheds as success rates decline elsewhere.

Currently, hunter success is low in coastal watersheds. Reasons for this include high costs associated with reaching coastal rivers, poor access, and poor bear visibility. However, as these watersheds are developed, access will improve and, depending on the forest harvesting regime, so will visibility. Since these bears congregate seasonally, they become very vulnerable to overharvesting if hunters are able to exploit them during these seasons. Since the extent of inter-watershed travel is unknown, the local and regional effects of overharvesting is also unknown. Suffice it to say that efforts must be made to protect coastal grizzlies from legal and illegal overharvesting.

1. Objectives

   - determine harvest rates for coastal grizzlies.

   - determine forestry practices that will reduce vulnerability of grizzly populations to hunting.

2. Hypothesis to be tested

   - Man-induced grizzly mortality is the primary reason for population declines in logged watersheds.

OTHER STUDIES

Grizzly mortality as a result of conflict with man becomes more significant as development intensifies. One of the major sources of mortality is associated with garbage management. As mentioned in the section dealing with food habits, grizzlies appear to be adaptable feeders: they will exploit high energy food sources when they are available. Most garbage dumps are high energy food sources. When bears are attracted into camps or garbage dumps and become habituated, they are a potential threat to human safety and are generally destroyed.

In coastal systems where remote camps are common, this problem becomes acute. Bears are frequently lured into camp garbage dumps and are either removed or destroyed. There is every possibility that grizzly bears are destroyed in remote camps without being reported to the Fish and Wildlife Branch.

Once bears become habituated to feeding on garbage, it is difficult to lead them back to wilderness life. Translocations are seldom successful. Hebert (unpubl. data) moved coastal grizzly bears by helicopter from a remote logging camp only to have them return to the same location. In one instance, an adult grizzly was moved 84 air kilometres, over mountains 2500 m high, into another drainage, and still returned to the capture site. The survival rate of relocated bears that do not return to their capture sites is unknown.

Survival depends on successfully establishing a new home range. Factors affecting success are the sex and age class of the relocated bear and the presence of other grizzlies in the new area. Survival is likely quite low in areas already occupied by grizzlies.

The obvious way of dealing with problem bear situations in coastal forests is to reduce their probability of becoming problems. Two major initiatives arise: proper waste management, and an information/education program directed at coastal camp workers to change existing attitudes towards bears.

Proper waste management in coastal forests would likely involve site-specific treatments that could include petroleum-fired incinerators, fenced (electric) garbage pits that are burned daily, as well as other methods.

Survival of coastal grizzlies in actively logged watersheds will be largely a function of the attitudes of the workers in the area. If loggers feel threatened by grizzlies, then confrontations will develop. However, bears and remote camps can be compatible. Harding and Nagy (1980) studied a population of grizzly bears that co-existed with extensive seismic exploration activity on a remote off-shore island in the Mackenzie River delta. Over four years of investigation, grizzlies only wandered into camps a total of six times, and, in each instance, bears were successfully chased off. Garbage was not a problem at any of these camps.

Sally Spencer (pers. comm.), staff wildlife biologist with B.C.F.P., is conducting research on coastal grizzly bears in association with Fish and Wildlife personnel from Region 5. She has spent some considerable time with loggers in her research area, showing films and slides, and discussing grizzly ecology. She feels that as loggers become familiar with bears, they take a greater interest in bears in the area and consider themselves stewards of grizzlies. This attitude is not surprising. As people become more familiar with a subject and see that they can play an active role in an important situation, they will generally become supportive.

Given that in coastal watersheds we may be dealing with small, relatively discrete populations of bears, it is important that each individual bear have as high a chance for survival as possible. This means eliminating garbage as a problem, establishing camps at sites that do not conflict with natural movements or seasonal concentrations, and developing positive attitudes in the minds of personnel in remote camps towards grizzly bears.

Objectives

- assess garbage management techniques to determine which are best for camps in coastal watersheds
- develop programs to enhance positive attitudes of coastal camp workers to grizzly bears.
- make recommendations on camp placement and timing of activity to avoid man-bear conflicts.

Proposed activity

1. Develop a comprehensive waste management policy of general application for all coastal development.
2. Develop an informative/education program to be delivered to all personnel working in coastal watersheds to minimize likelihood of man-bear conflicts and enhance the attitudes of coastal workers towards grizzlies.

PRIORITIES AND RECOMMENDATIONS

A number of priority topics can be identified. These topics can be separated into 3 categories, based on the government branch responsible for action.

WILDLIFE RESEARCH

Priority	Topic	Rationale
1.	Determine population discreteness of coastal grizzlies.	To be determined before effective management can be carried out.
2	Determine the nature, duration and extent of dispersal of coastal grizzlies.	To allow for effective population management.
3.	Determine the seasonal habitat and requirements of coastal grizzlies.	To allow for effective habitat protection action.

4.	Assess impacts of different forest practices on grizzly bear habitat and management.	The long-term survival of coastal grizzlies may depend on developing compatible forest harvesting regimes.
5.	Determine ecological requirement for denning habitat and denning biology.	To afford protection to coastal grizzlies during this critical period.
6.	Determine if the concept of critical breeding areas applies to coastal grizzlies.	To protect such areas if they exist.

INFORMATION SERVICES

Priority	Topic	Rationale
1	Develop an intensive information/education program to be delivered to all personnel working in coastal watersheds.	To minimize the likelihood of man-bear conflicts and enhance attitudes towards grizzlies.

HABITAT-PROTECTION - WASTE MANAGEMENT

Priority	Topic	Rationale
1	Develop and implement a remote camp garbage policy tailored to address present and future coastal watershed activity.	To minimize the likelihood of habituating bears to garbage.

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APPENDIX A - Common and scientific names of animal and plant species mentioned in the text.

Common name	Scientific Name
grizzly bear	*Ursus arctos*
salmon	*Oncorhynchus* sp.
alder	*Alnus* sp.
amabalis fir	*Abies amabalis*
bunchberry	*Cornus canadensis*
devil's club	*Oplopanax horridus*
Douglas fir	*Pseudotsuga menziesii*
false azalea	*Menziesia ferruginea*
huckleberry	*Vaccinium* sp.
salmonberry	*Rubus spectabilis*
sedge	Cyperaceae
Sitka spruce	*Picea sitchensis*
skunk cabbage	*Lysichitum americanum*
soapberry	*Shepherdia canadensis*
western hemlock	*Tsuga heterophylla*
western red cedar	*Thuja plicata*

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